RETURN TO
RADIO PHYSICS LAB.

BRUSH

OPERATING INSTRUCTIONS

recorder mark II

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This instruction book applies to
Recorder Mark II Serial No. 406 and above.

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Claim for damage in shipment

The instrument should be examined as soon as it is received. If it is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained from the claim agent, and this report should be forwarded to us. We will then advise you of the disposition to be made of the equipment and arrange for repair or replacement. Include model number, type number and serial number when referring to this instrument for any reason.

If any fault develops

1. Notify the nearest factory branch service station, address on the next page, giving full details of the difficulty, and include the model number, type number and serial number. Upon receipt of this information, we will give you service instructions or issue a material return authorization card.
2. You may request any necessary instrument packaging by telling us what cartons you need. These will be sent to you no charge.
3. Upon receipt of shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

WARRANTY

Each instrument manufactured by Brush Instruments, Division of Clevite Corporation, is warranted to be free from defects in material and workmanship and to operate in accordance with the published specifications when used with the recommended Brush associate equipment and with Brush chart paper. Liability under this warranty is limited to servicing or adjusting any instrument returned to a factory branch service station for that purpose and to replacing any defective parts thereof except tubes, fuses, and batteries.

This warranty is effective for one year after delivery to the original purchaser. When the instrument is returned transportation charges are to be prepaid by the original purchaser. If defective operation has been caused by misuse or abnormal conditions of operation, repairs will be billed at our current rate. In this case an estimate will be submitted before work is started.

SUPPLIES AND SERVICE

Brush Instruments factory branch offices and service stations:

EAST

ARLINGTON
561 - 23rd Street, South
Arlington 2, Virginia
Phone: OTis 4-5912

BOSTON
677 Worcester Street
Natick, Massachusetts
Phone: OLympic 3-8850

MIDWEST

CLEVELAND
37th and Perkins
Cleveland 14, Ohio
Phone: ENdicott 1-3315

WEST

LOS ANGELES
1960 South La Cienega Blvd.
Los Angeles 34, California
Phone: TExas 0-7517

SAN FRANCISCO
61 Renato Court
Redwood City, California
Phone: EMerson 9-5581

RECORDER MARK II

The Brush Recorder Mark II provides immediately visible, permanent chart recordings on two channels over a wide amplitude and frequency range (d.c. to 100 cps). The Recorder includes oscillograph and amplifiers as an integral unit which is operated from any a.c. outlet through one power cord.

The Recorder is designed for a minimum of operator adjustments, with three simple controls per channel, and self-cleaning, self-priming pens. Pushbuttons permit instant selection of chart speeds (1, 5, 25 and 125 mm/sec). Other features are fast, front-loading change of chart paper, unitized components, and a slide-out chassis for quick inspection.

Extreme stability and high sensitivity are featured in the Recorder; a 10 millivolt input signal produces a pen deflection of one chart line (mm).

SPECIFICATIONS

Sensitivity	10 millivolts per chart line (mm). Full scale deflection from chart center ±200 millivolts.
Sensitivity steps	.01, .02, .05, .1, .2, .5, 1, 2, 5, and 10 volts per chart line (mm). Maximum attenuator error 1% with balanced input.
Measurement range	
Single-ended input (5 megohm)	.010 volt to 400 volts.
Balanced input (10 megohm)	.010 volt to 400 volts, side to side, allowable voltage off-ground at any attenuator step is 1000 x volts per chart line switch setting up to 500 volts off-ground.
Common mode rejection	Better than 1000 to 1, attenuator set in .01 volt per chart line position.
Zero line stability	Less than ½ chart line (mm) per hour. Total drift over eight hour period not more than one chart line (mm).
Noise	Not noticeable on chart with shorted input.
Pen bias	Permits positioning of pen on chart, ±20 chart lines (mm). Effective for either single-ended or balanced input.
Frequency response	The recorded peak-to-peak amplitude of a constant voltage sine wave will be within ±1 chart line (mm) of a nominal 10 lines from d.c. to 100 cps.
Maximum amplitude	40 lines (mm) peak-to-peak, d.c. to 40 cps. 20 lines (mm) peak-to-peak, d.c. to 70 cps. 10 lines (mm) peak-to-peak, d.c. to 100 cps.
Trace linearity	D.C. within 1% full chart width. A.C. within 2% full chart width, any frequency within limits of maximum amplitude for ink writing.
Trace width	0.015″ with Model RA 2821 30 pen.
Writing method	Ink.
Number of recording channels	2.
Number of event channels	2. Actuated by external switch.
Channel width	40 mm (40 divisions).

Chart speeds	1, 5, 25, and 125 mm per second.
Chart supply	300 feet long x 3.718″ wide. Model RA 2921 32.
Chart speed regulation	Synchronous motor, direct drive.
Operating temperature range, ambient	0° C to 55° C.
Power requirements	105 volts-125 volts, 60 cps, 135 watts at 115 volts.
Tubes	1-6BW4, 2-12B4A, 2-12AT7, 2-12AX7, 1-5651, and 2-5687.
Input terminals	
Front (signal)	Binding posts.
Rear (event marker)	Binding posts.
Dimensions	12⅝″ wide x 12″ high x 13½″ deep.
Net weight	32 pounds.
Shipping weight	38 pounds.

OPERATING SUPPLIES

DESCRIPTION	BRUSH PART NO.
Chart Paper—Ink—2 Channel—300 ft. long.	RA 2921 32
Ink—Red—2 oz.—in Mark II Ink Reservoir	RA 2761 02
Pens—Ink (4)	~~RA 2821 30~~ RA-2821-32

Fig. 1. Controls—Front Panel.

OPERATION

(See Figure 1.)

1. Connect power cable to power source. Turn POWER switch "on", depress CHART SPEED "off" button, and allow Recorder to warm up for 15 minutes.
2. Turn VOLTS/CHART LINE switches "off", depress CHART SPEED "5" button, and bring pen to chart center (or other desired position) with PEN BIAS control. To stop Recorder, depress CHART SPEED "off" button.
3. Connect input signal to INPUT "1" and "2" terminals. For single-ended input, connect GROUND and INPUT "1" terminals with ground strap. For balanced (doubled-ended) input, remove ground strap.
4. Turn SENSITIVITY control counterclockwise until a switch is actuated at "X1" position. Depress CHART SPEED button for desired speed, and set VOLTS/CHART LINE switch in desired position.

   When SENSITIVITY control is in "X1" position, recorded signal is equal to product of pen deflection in chart lines (mm) times VOLTS/CHART LINE switch setting. This position of SENSITIVITY control adjusts sensitivity of amplifier so that value of recorded signal is read directly as the product of pen deflection and VOLTS/CHART LINE switch setting.

   If other sensitivity values are desired, or if external calibration is used, SENSITIVITY control may be turned clockwise from "X1" position until desired pen deflection is obtained.

EVENT MARKERS

Power for Event Markers is supplied internally from a 24 volt d.c. supply; events are recorded by closure of external switches. Connections for Event Markers are made through EVENT terminals on rear of Recorder.

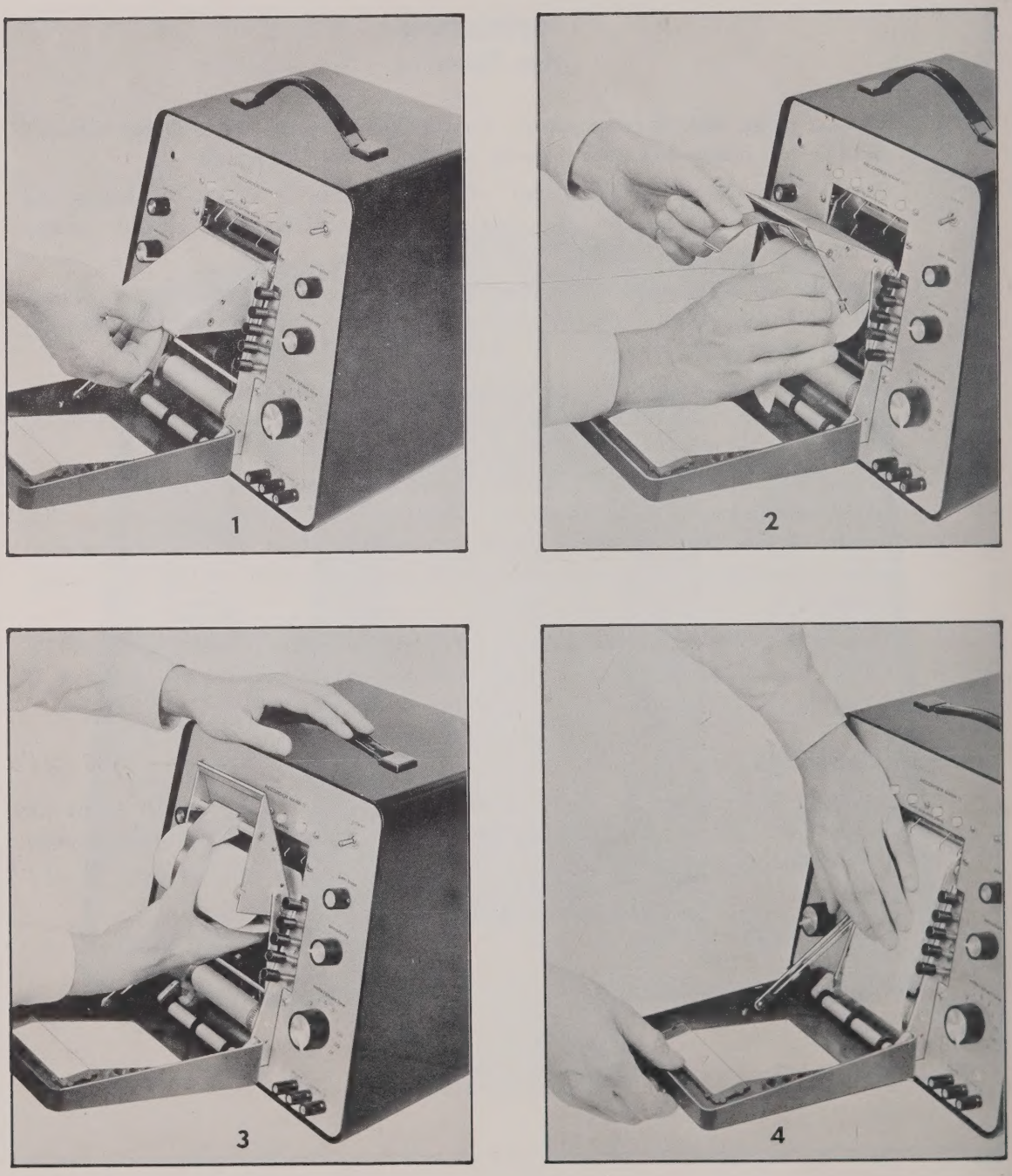


Fig. 2. Loading Chart Paper.

TO LOAD CHART PAPER (See Figure 2.)

1. Pull front door outward and downward to limit. Pull writing table outward and upward to limit (**1**). Lift paper tension arm and remove paper supply shaft.
2. Insert paper supply shaft in paper supply. Lift paper tension arm and position paper supply shaft in slots on writing table side plates, with about 4″ of paper rolling downward (**2**). Replace paper tension arm on paper supply and remove all slack from behind tension arm. Feed chart paper up over writing table and pull paper to end of table (**3**).
3. Return writing table to operating position, place end of chart paper between drive roll and tension roll (**4**), then return front door to operating position. Operate Recorder for a few seconds at 125 mm/sec to align chart paper on writing table.

TO CHANGE INK RESERVOIR (See Figure 3.)

1. Open rear door, and loosen screws in clamp securing ink reservoir to chassis. Lift reservoir from clamp, and unscrew reservoir from cover (**1**).
2. Remove cover from replacement reservoir. Screw replacement reservoir securely into cover in the recorder. Place reservoir in clamp, tighten clamp screws, and close rear door.
3. Open front door and press primer buttons until ink flows from all pens (**2**). Close front door.

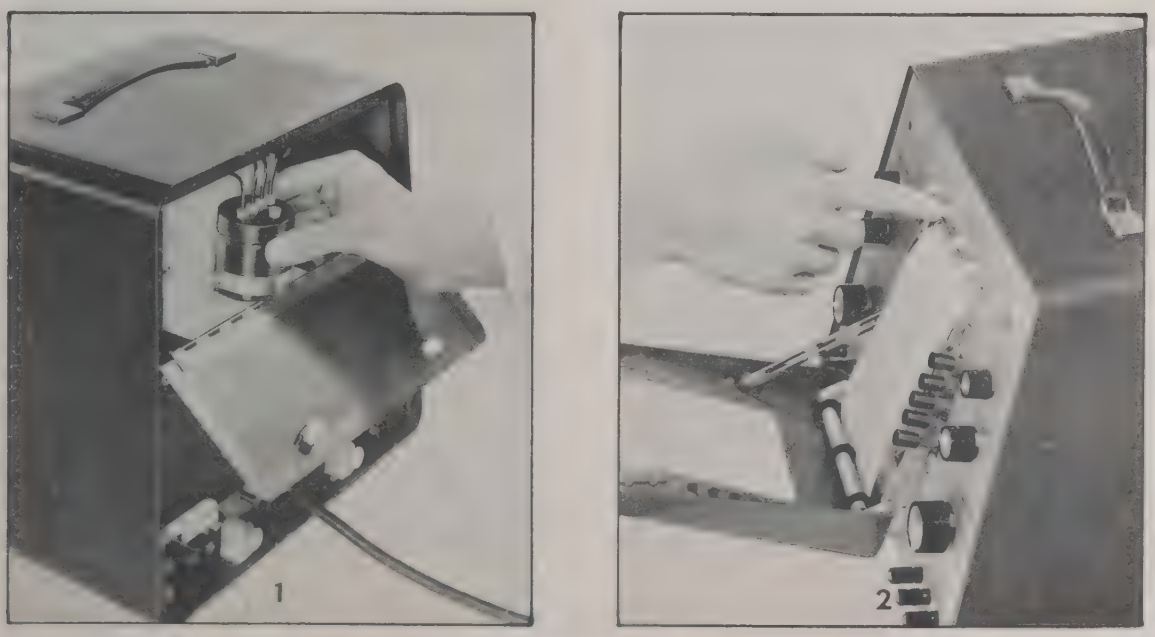


Fig. 3. Filling Ink Reservoir.

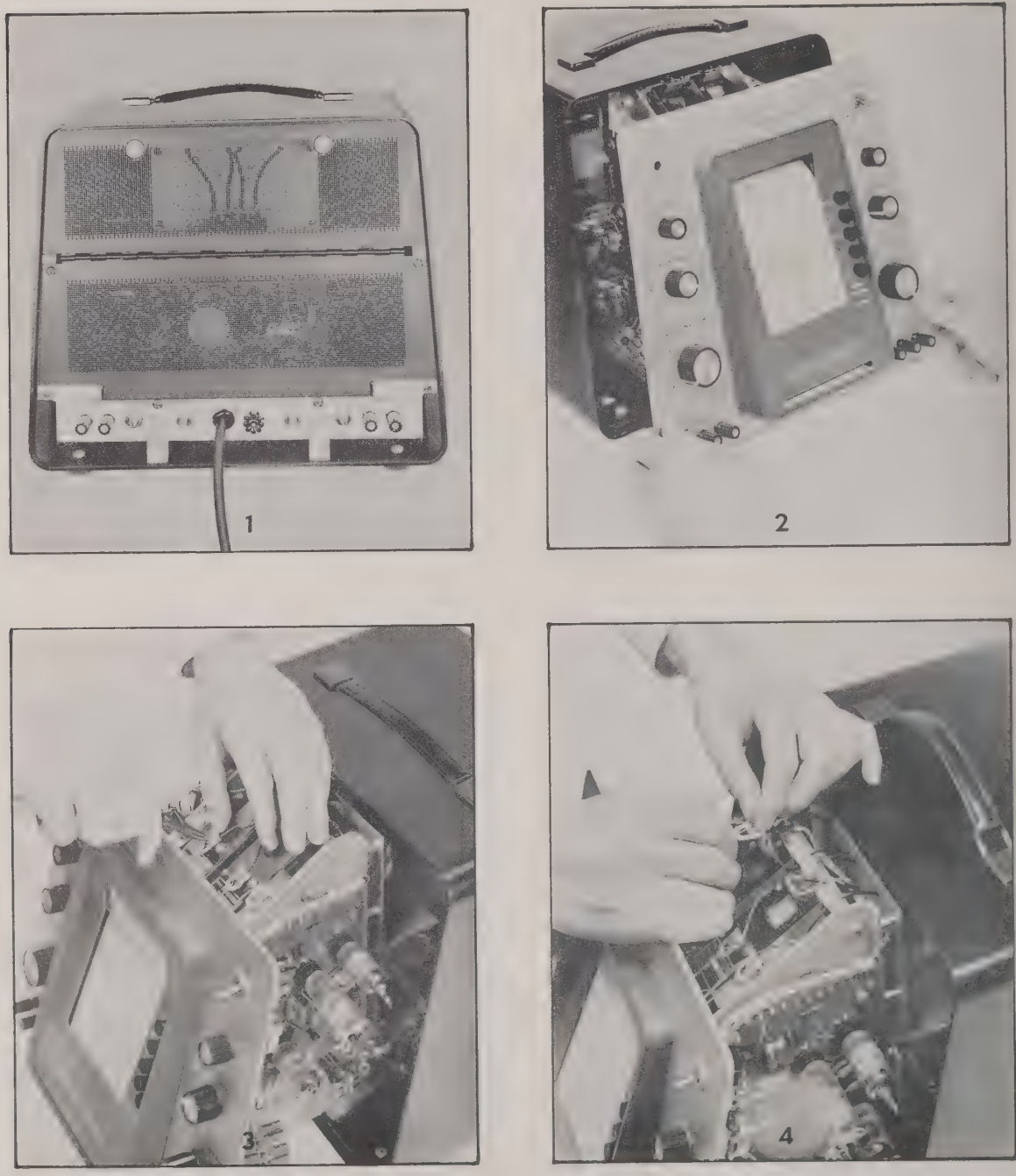


Fig. 4. Changing Pens.

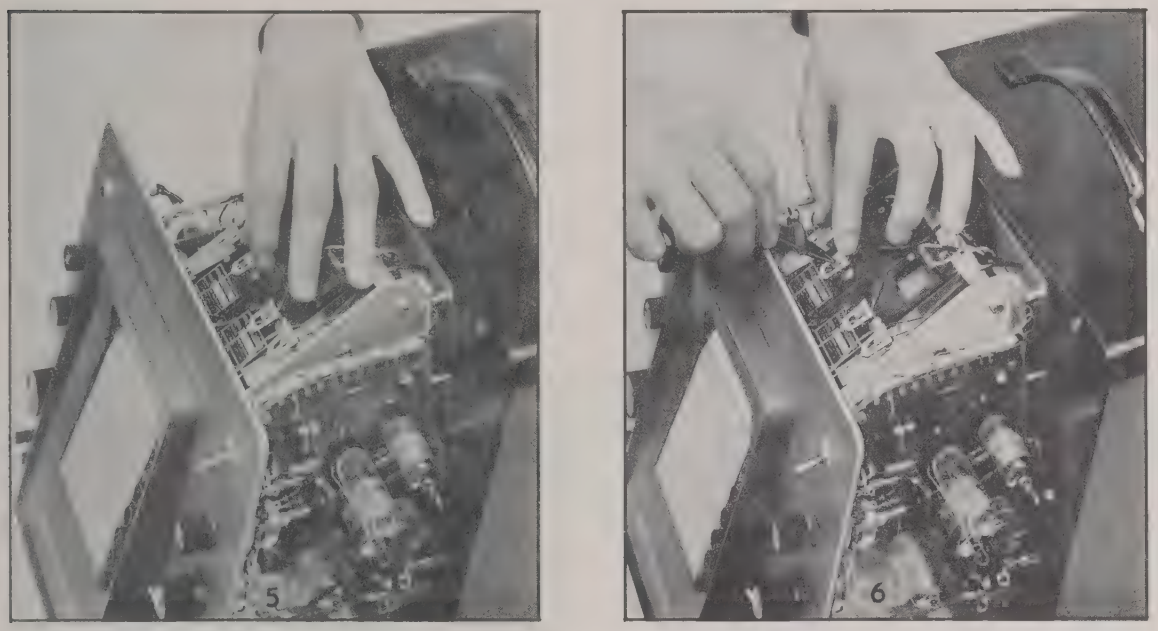


Fig. 4. Changing Pens (Cont'd).

PENS
(See Figure 4.)

Procedures below must be followed for proper operation of Recorder. To prevent damage to penholder or upper bearing of penmotor, do not force penholder from vertical position or spread grooved sides excessively.

TO REMOVE PENS

1. Loosen knurled screws securing Recorder in case (**1**) and slide Recorder from case (**2**).
2. Spread penholder slightly with Pen Mounting Tool, and pull tongue of pen from penholder (**3**). Disconnect capillary tube from pen (**4**).

TO MOUNT PENS

1. Connect capillary tube to pen (**4**). Position yoke of pen over penholder, aligning tongue of pen with grooves in penholder (**5**). Spread penholder slightly with Pen Mounting Tool and press tongue of pen as far as possible into penholder (**6**).
2. If one signal pen tip is farther forward than the other (both pens seated in penholders), draw longer pen back until pen tips are aligned. Align Event Marker pen tips with intersection points of outer printed lines on chart and curved paths of signal pen tips. Press primer button until ink flows, return Recorder to case, and secure with knurled screws.

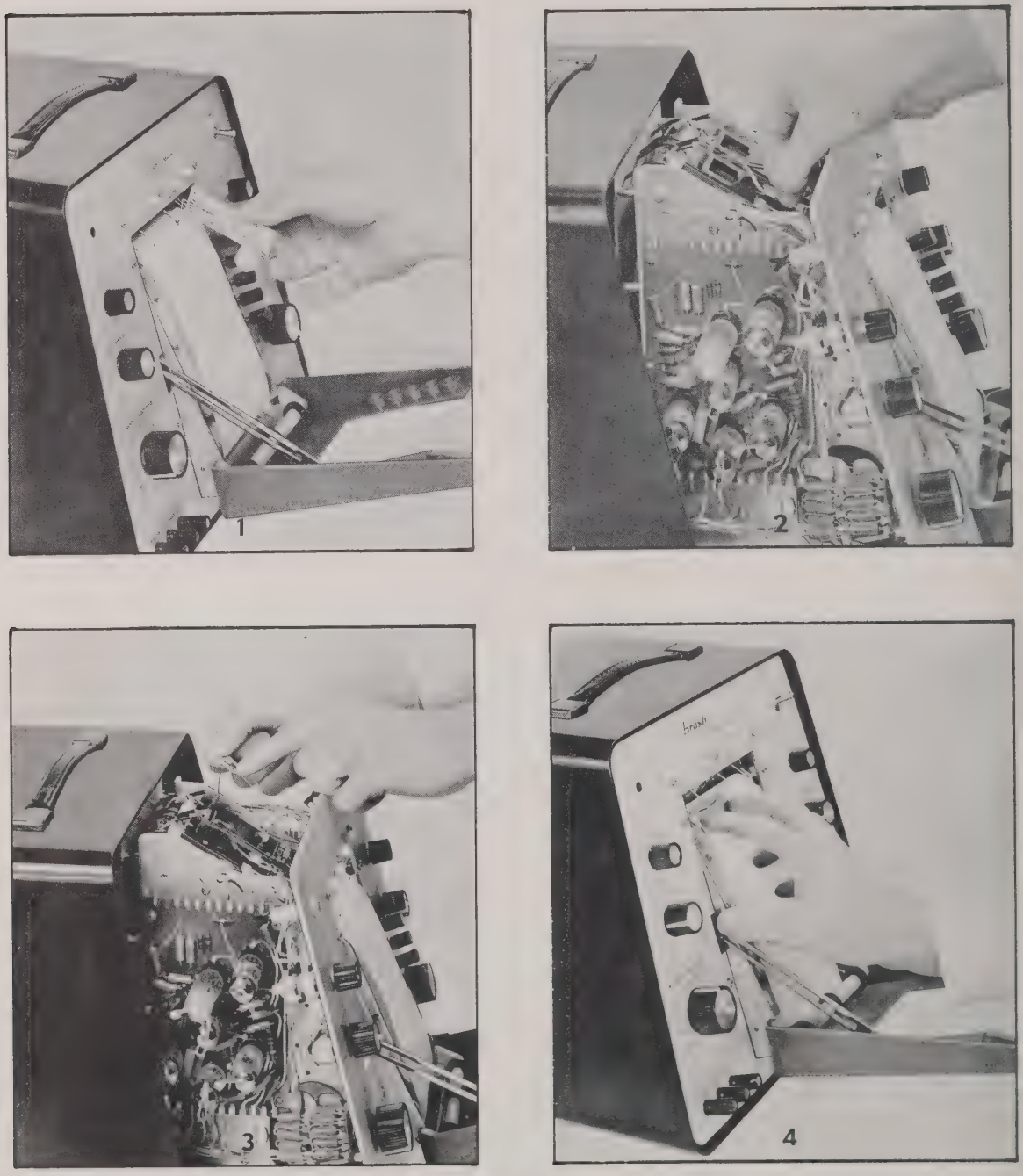


Fig. 5. Adjusting Pens.

TO ADJUST PEN PRESSURE
(See Figure 5.)

For optimum writing from d.c. to 100 cps, pen tip should apply from .5 to .75 gram pressure to chart paper. If most recordings will be made at frequencies from d.c. to 10 cps, with maximum amplitude of 10 mm peak to peak, a pen pressure of .35 gram is recommended. If most recordings will be made at frequencies from 10 to 100 cps, a pen pressure of 1.25 grams may be used.

Pen pressure is measured by placing hook of Gram Gage under pen 1/32" behind pen tip; reading is taken just as pen tip is lifted from paper (**1**).

1. If pen pressure is too *great,* lift pen tip from paper a few times (exerting upward pressure on pen yoke) until correct gage reading is obtained (**2**).
2. If pen pressure is too *low,* remove pen from penholder and bend tongue upward slightly in relation to yoke. Mount pen and measure pen pressure. Repeat adjustment until correct pressure is obtained (**3**).

TO LAP PENS
(See Figure 5.)

When new pens are installed on the Recorder, pens should be lapped as described below for satisfactory writing at all signal frequencies and chart speeds.

1. Open Recorder front door to release tension roll from drive roll. (This prevents chart paper from moving.) Press primer button until ink flows freely from pen tip.
2. Connect signal of approximately 60 cps to INPUT terminals. Depress CHART SPEED "5" button and set VOLTS/CHART LINE switch in position required to produce a pen deflection of 20 chart lines (mm) peak to peak. Operate Recorder for approximately 15 seconds with strip of abrasive (supplied with pen) held flat on writing table under pen tip (**4**).
3. Remove strip of abrasive and close front door, applying tension roll to drive roll. Test Recorder for uniform pen trace at various frequencies and at all chart paper speeds. Repeat lapping process until satisfactory pen trace is obtained.

INK SYSTEM

A completely enclosed ink system is used on the Recorder; this prevents foreign material from entering the ink system, and prevents excessive evaporation of ink. However, for optimum performance, the cleaning procedures described below should be followed after every 3 months of operation.

Fig. 6. Cleaning Pen.

TO CLEAN INK PENS (See Figure 6.)

The pen tip is tapered inside; water must enter the pen through the pen tip. Water flowing through pen in wrong direction will cause further clogging.

1. With pen removed from Recorder, fill Brush plastic syringe with water, and insert pen tip in syringe needle.
2. Depress syringe plunger, forcing water through pen tip and pen until pen is cleared. If necessary, soak pen in water over night, then repeat Cleaning Procedure.

TO CLEAN INK LINES

Ink lines (capillary tubes) should be rinsed periodically with water to dispose of sediment.

1. Open rear door of Recorder. Loosen screws on clamp securing reservoir to chassis, and lift reservoir from clamp. Unscrew reservoir from cover.
2. Soak reservoir in water and rinse thoroughly. Fill reservoir with water to within ¼″ of top. Screw reservoir securely into cover, and position reservoir in clamp on chassis.
3. Remove all pens from Recorder. Depress and release primer buttons on front of Recorder to pump water from reservoir through ink lines, catching water in a suitable container as it is expelled from lines.
4. When ink lines are rinsed thoroughly, lift reservoir from clamp, and unscrew reservoir from cover. Screw replacement reservoir into cover and place in clamp on chassis. Tighten clamp screws securely, and close rear door.
5. Install pens on Recorder and, with front door open, depress and release primer buttons to expell water in lines and prime pens, catching water in a suitable container. When ink flows freely from all pens as primer buttons are depressed, close front door of Recorder.

PRECAUTIONS

1. Keep watches, chronometers, and similar instruments away from Recorder.
2. Do not drop Recorder or tap penmotors with a hammer.
3. Prevent dirt, dust, metal filings, and the like from entering penmotors.
4. If either penmotor is damaged, remove from Recorder and send to factory for repairs. Special equipment is required for magnetization and coil alignment.

LUBRICATION (Every 250 hours of operation)

Remove chart paper and, with writing table pulled upward to limit, lift one side of gear cover with a screwdriver. Tilt cover and remove from Recorder. Apply lubricant sparingly. Use Stanoil #35 or Gulfcrest "C" lubricant for wick type oilers on motor and sintered bearings in transmission; use Lubriplate (140 or APG 90) for exposed gears and clutches. Replace gear cover and chart paper.

ADJUSTMENT OF HUM BALANCE CONTROL (See Figure 7.)

When the Recorder is shipped from the factory, the hum balance control is so adjusted that no appreciable hum or noise appears on recording (with no input signal applied).

1. To reduce noise or hum indicated on chart remove rear cover of Recorder, connect INPUT "1" and "2" terminals to GROUND (both channels), connect power cable to power source and turn POWER switch "on". Allow Recorder to warm up for 15 minutes.
2. Depress CHART SPEED "5" button and, with no signal connected to Recorder channels, adjust hum balance control R-64 to produce minimum trace on *both* channels. Turn POWER switch "off", disconnect power cable from power source, and replace rear cover of Recorder.

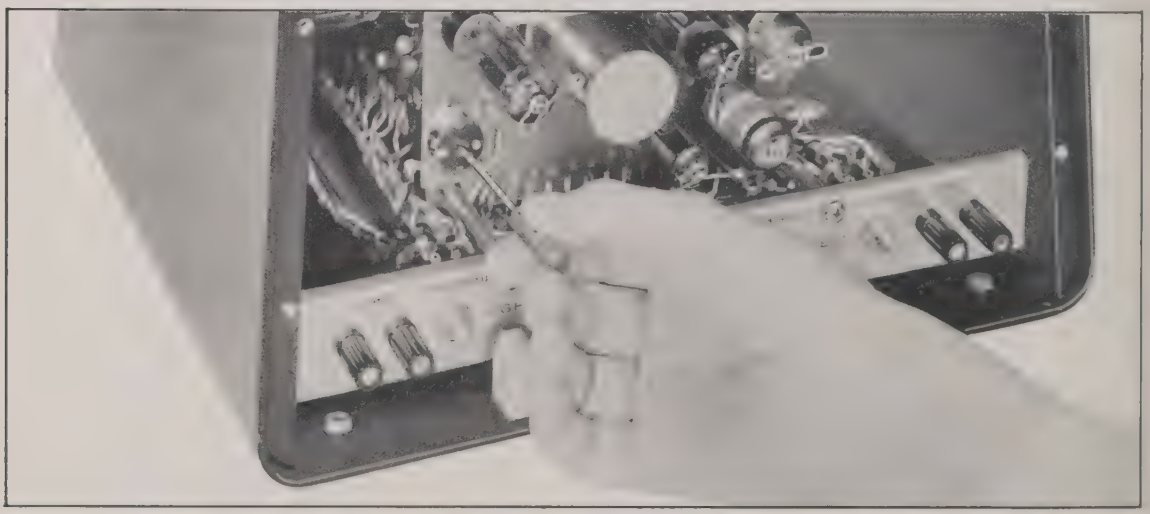


Fig. 7. Adjustment of Hum Balance Control.

TUBE REPLACEMENT (See Figure 8.)

All tubes in the Recorder are accessible for replacement when the case is removed. No adjustment is required following replacement of tubes in the Recorder power supply. However, when a tube has been replaced in an amplifier channel, that channel must be balanced and calibrated, as described below.

1. Connect Recorder to proper power source, turn POWER switch "on", and allow Recorder to warm up for 15 minutes.

2. Depress CHART SPEED "1" button, turn SENSITIVITY control full clockwise, and bring pen approximately to chart center with PEN BIAS control.

3. Turn BALANCE control, on rear panel, to extreme counterclockwise position. Rapidly rotate SENSITIVITY control counterclockwise, then clockwise, while turning BALANCE control slowly clockwise until no pen deflection is noted. Center pen on chart with PEN BIAS control.

4. Connect a known d.c. voltage to INPUT "1" and "2" terminals. With SENSITIVITY control in "X1" position, turn VOLTS/CHART LINE switch clockwise until
   PEN DEFLECTION IN CHART LINES $\times$ VOLTS/CHART LINE SWITCH SETTING $=$ KNOWN D.C. VOLTAGE USED.
   (If a 1.35 volt mercury cell is used, and if the VOLTS/CHART LINE switch is in ".1" position, pen deflection should be 13.5 chart lines.)

5. If product of pen deflection and VOLTS/CHART LINE switch setting is not equal to d.c. voltage used, calibrated gain adjustment is improperly set. Reset calibrated gain adjustment (located behind PEN BIAS control) until product of pen deflection and VOLTS/CHART LINE switch setting is equal to d.c. voltage used.

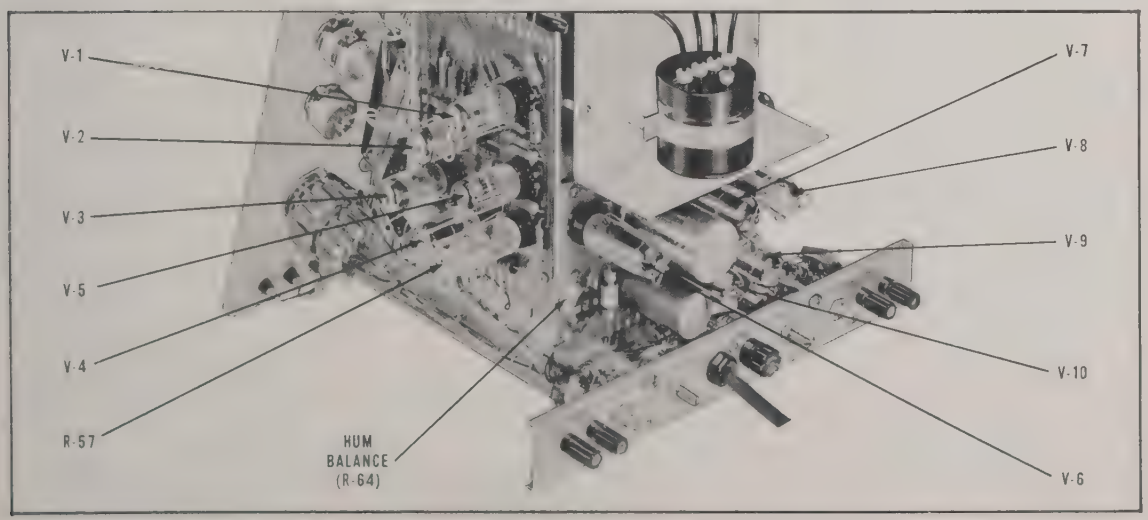


Fig. 8. Tube Identification.

TROUBLE SHOOTING

The chart below lists symptoms and probable causes of improper operation of the Recorder or failure of the Recorder to operate, as well as probable remedies for unsatisfactory operating conditions.

Conditions described in the chart are for a Brush Recorder Mark II, operating from a 60 cps 115 volt power source. Procedures suggested in "Remedy" column may be performed by operating personnel.

Before checking trouble symptoms against chart, see that all quick connectors are securely connected to wiring boards.

GENERAL

SYMPTOM	CAUSE	REMEDY
1. Recorder does not operate; pilot lamp does not light.	a. Power cable disconnected. b. No power line voltage. c. Fuse open. d. Defective POWER switch.	a. Connect power cable. b. Connect Recorder to proper power source. c. Replace fuse. d. Replace defective switch.
2. Recorder does not operate; pilot lamp lights.	a. Rectifier tube 6BW4 defective. b. Cabling defective between amplifier and penmotor. c. Defective 12B4A, 12AT7, or 12AX7 tube. d. Defective 3TF4 ballast resistor. e. Interspeed muting switch closed or defective.	a. Replace defective tube. b. Repair cable. c. Replace defective tube. d. Replace defective resistor. e. Depress appropriate CHART SPEED button, or replace defective switch.
AMPLIFIER SECTION		
1. Amplifier operates, and can be balanced; noise or hum indicated on chart.	a. Hum balance control out of adjustment. b. Lack of shielding at amplifier input. c. Defective 12AX7, 12AT7, or 5687 tube (cathode to heater leakage). d. Defective filter capacitor. e. Unregulated plate voltage.	a. Adjust as described in Operating Instructions b. Shield input terminals. c. Replace defective tubes, balance and calibrate amplifier channel. d. See "Power Supply", below. e. See "Power Supply", below.

SYMPTOM	CAUSE	REMEDY
2. Amplifier operates and can be balanced; drifts excessively.	a. Power line voltage below 105v or above 125v. b. Defective 12AX7 or 12AT7 tubes. c. +B to −B voltage varies.	a. Connect Recorder to proper power source. b. Replace defective tubes, balance and calibrate amplifier channel. c. See "Power Supply", below.
3. Amplifier operates, and can be balanced; PEN BIAS control does not operate.	a. Defective 12AX7 tube. b. Defective 3TF4 ballast resistor. c. Defective PEN BIAS control. d. Open resistor from arm of PEN BIAS control to −B.	a. Replace defective tube. b. Replace defective resistor. c. Replace defective control. d. Replace defective resistor.
4. Maximum sensitivity less than 20 chart lines (mm) with SENSITIVITY control fully clockwise.	a. Insufficient power line voltage. b. Weak 12AX7, 12AT7, 5687, 6BW4, or 12B4A tube. c. Defective resistor between cathode of 12AX7 tube and calibrated gain switch on SENSITIVITY control.	a. Connect Recorder to proper power source. b. Locate and replace defective tube. c. Replace defective resistor.
5. Sensitivity at "XI" position of SENSITIVITY control inaccurate.	a. Weak 12AX7, 12AT7, 5687, 6BW4, or 12B4A tube. b. Calibrated gain control (on rear of PEN BIAS control) improperly adjusted. c. Defective resistor between cathode of 12AX7 tube and calibrated gain "XI" switch on SENSITIVITY control.	a. Locate and replace defective tube. b. Reset calibrated gain control as described under "Tube Replacement". c. Replace defective resistor and reset calibrated gain control as described under "Tube Replacement".
6. Amplifier can be balanced and calibrated, but is nonlinear.	a. Defective 12AX7, 12AT7, or 5687 tubes.	a. Replace defective tubes, balance and calibrate amplifier channel.
7. Sensitivity incorrect at certain VOLTS/CHART LINE switch positions.	a. Defective resistor in attenuator network.	a. Replace defective resistor.
8. Amplifier channel cannot be frequency compensated to penmotor.	a. Defective resistor or capacitor in compensation network.	a. Locate and replace defective resistor or capacitor.

POWER SUPPLY SECTION

SYMPTOM	CAUSE	REMEDY
1. +B to −B regulated voltage varies, is erratic, or is of wrong value.	a. Insufficient power line voltage. b. Defective 6BW4, 12B4A, 12AX7, or 5651 tube. c. Defective filter capacitor. d. Defective resistor or capacitor.	a. Connect Recorder to proper power source. b. Locate and replace defective tube. c. Replace defective capacitor. d. Replace defective resistor or capacitor.
RECORDER SECTION		
1. Crosstalk between penmotors.	a. Penmotor circuit grounded.	a. Locate and eliminate ground.
2. Pen continues to indicate signal when CHART SPEED "off" button is depressed.	a. Defective interspeed muting switch.	a. Repair or replace defective switch.
3. Pen cannot be primed with primer button.	a. No ink in ink reservoir. b. Clogged pen or ink system.	a. Install replacement reservoir. b. Clean pen or ink system as described in Operating Instructions.
4. Chart drive motor does not operate, POWER switch indicator is lighted.	a. Defective motor.	a. Replace defective motor.
5. CHART SPEED buttons will not remain engaged.	a. Broken flat spring on latching bar. b. Worn latching bar.	a. Replace broken spring. b. Replace CHART SPEED pushbutton assembly.
6. CHART SPEED button will not release.	a. Broken coil spring on pushbutton assembly.	a. Replace CHART SPEED pushbutton assembly.
7. CHART SPEED button does not select proper chart speed.	a. Inoperative transmission.	a. Return Recorder to factory service department for repair.
8. Chart does not move when CHART SPEED buttons are depressed.	a. Defective gear in gear train or transmission.	a. Return Recorder to factory service department for repair.

PARTS IDENTIFICATION

Components of the Brush Recorder Mark II may be identified by means of Figures 9, 10, and 11 below . The symbols appearing on these illustrations are correlated with the Parts List and the Schematic Diagram.

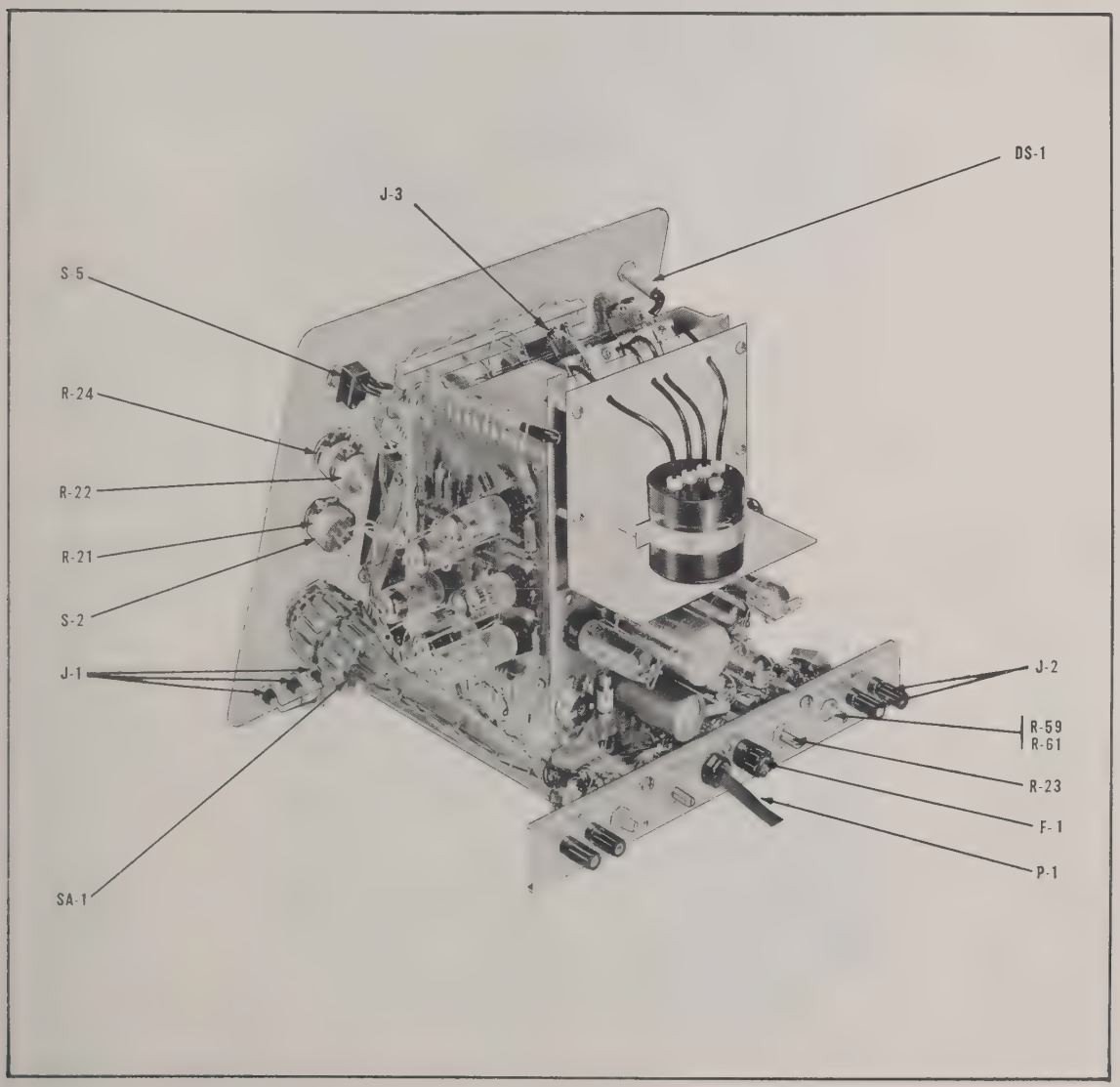


Fig. 9. Brush Recorder Mark II with Cover Removed.

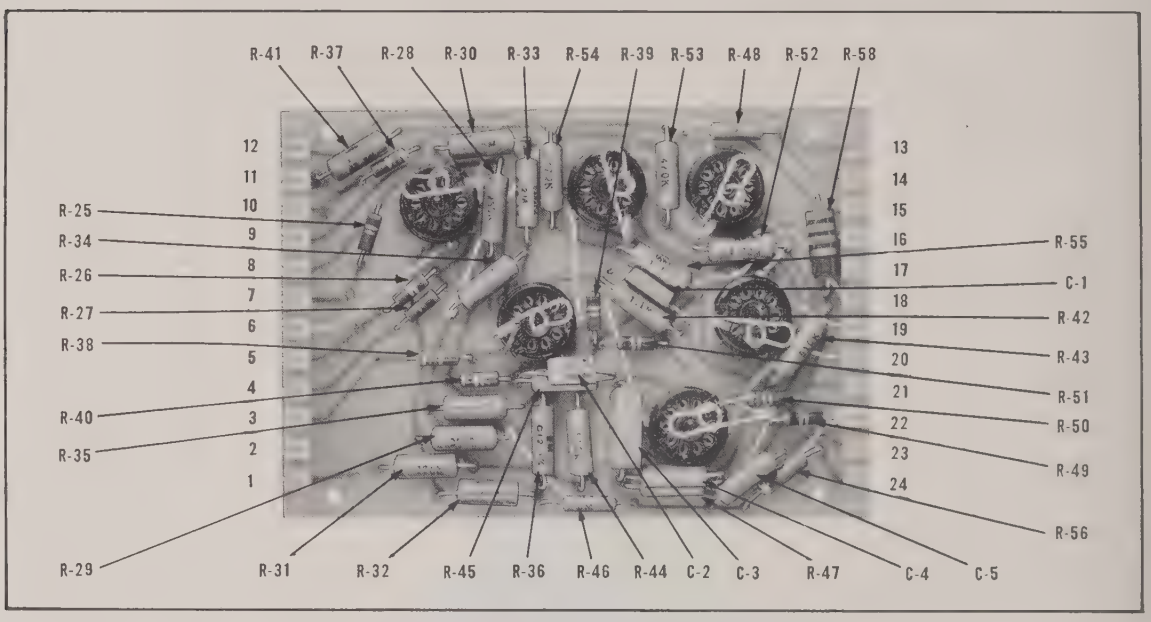


Fig. 10. Printed Wiring Board (Amplifier Channel).

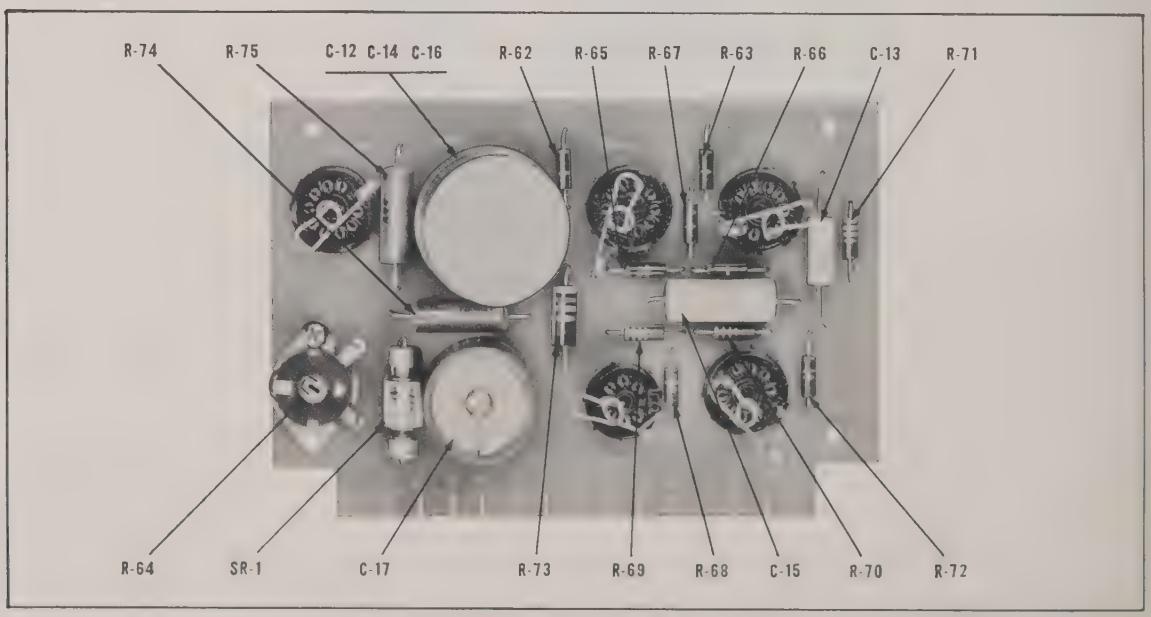


Fig. 11. Printed Wiring Board (Power Supply).

It is recommended that, for major servicing or repairs, the instrument be returned to a factory service station where facilities are available to restore it to its original condition. In the event that this is impractical or the repair is of a minor nature, the following parts list and schematic diagram are designed to assist in servicing and repairing. In order to assure prompt and satisfactory delivery of replacement parts, it is very necessary that you include the following information with your order:

1. The name and serial number of the instrument for which the parts are to be used. For example,
   "Brush Recorder Mark II,
   Model RD 2521 00, Serial No. 123".
2. The following specific information on the desired parts:
   Description
   Value (electrical)
   Brush Part No.

Note: Do not use the SYMBOL NO. for identifying desired parts on your order.

PARTS LIST

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
B-1	Motor, Drive		227253
C-1	Capacitor, Mica	100 mmfd, ± 5%, 500V	5-117264-101
C-2	Capacitor, Mica	100 mmfd, ± 5%, 500V	5-117264-101
C-3	Capacitor, Mica	.0033 mfd, ± 5%, 500V	5-117265-332
C-4	Capacitor, Mica	470 mmfd, ± 5%, 500V	5-117264-471
C-5	Capacitor, Mica	680 mmfd, ± 5%, 500V	5-117264-681
C-6	Capacitor, Mica	.0024 mfd, ± 5%, 500V	5-122233-242
C-8	Capacitor, Mylar	.01 mfd, ± 20%, 400V	20-125905-103
C-9	Capacitor, Mylar	.01 mfd, ± 20%, 400V	20-125905-103
C-10	Capacitor, Paper	.25 mfd, ± 10%, 200V	10-120554-254
C-11	Capacitor, Paper	.25 mfd, ± 10%, 200V	10-120554-254
C-12	Capacitor, Electrolytic (⅓ Triple Section)	20 mfd, 450V	127152
C-13	Capacitor, Mylar	.01 mfd, ± 10%, 400V	10-125905-103
C-15	Capacitor, Mylar	.1 mfd, ± 10%, 400V	10-125905-104
C-14	Capacitor, Electrolytic (⅓ Triple Section)	20 mfd, 450V	(Part of C-12)
C-16	Capacitor, Electrolytic (⅓ Triple Section)	20 mfd, 450V	(Part of C-12)
C-17	Capacitor, Electrolytic	100 mfd, 50V	128020-107
DS-1	Neon Lamp		126621
F-1	Fuse	Type 3AG, "Quick Acting", 3A, 250V	102625-9

PARTS LIST (Cont'd)

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
J-1	Binding Posts	GR Type	126395-3
J-2	Binding Posts	GR Type	126395-3
J-3	Connector, Female, 3 Pin		126001-1
K-1	Relay, Marker Coil	(Left Event Marker)	227665-910
M-1	Penmotor		425939-501-133
P-1	Cable, Power Input		126295-7
R-1	Resistor, Precision	2.5M, ± 0.5%, ½W	50-117802-2504
R-2	Resistor, Precision	1.5M, ± 0.5%, ½W	50-117802-1504
R-3	Resistor, Precision	500K, ± 0.5%, ½W	50-117802-5003
R-4	Resistor, Precision	250K, ± 0.5%, ½W	50-117802-2503
R-5	Resistor, Precision	150K, ± 0.5%, ½W	50-117802-1503
R-6	Resistor, Precision	50K, ± 0.5%, ½W	50-117802-5002
R-7	Resistor, Precision	25K, ± 0.5%, ½W	50-117802-2502
R-8	Resistor, Precision	15K, ± 0.5%, ½W	50-117802-1502
R-9	Resistor, Precision	5.0K, ± 0.5%, ½W	50-117802-5001
R-10	Resistor, Precision	5.0K, ± 0.5%, ½W	50-117802-5001
R-11	Resistor, Precision	5.0K, ± 0.5%, ½W	50-117802-5001
R-12	Resistor, Precision	5.0K, ± 0.5%, ½W	50-117802-5001
R-13	Resistor, Precision	15K, ± 0.5%, ½W	50-117802-1502
R-14	Resistor, Precision	25K, ± 0.5%, ½W	50-117802-2502
R-15	Resistor, Precision	50K, ± 0.5%, ½W	50-117802-5002
R-16	Resistor, Precision	150K, ± 0.5%, ½W	50-117802-1503
R-17	Resistor, Precision	250K, ± 0.5%, ½W	50-117802-2503
R-18	Resistor, Precision	500K, ± 0.5%, ½W	50-117802-5003
R-19	Resistor, Precision	1.5M, ± 0.5%, ½W	50-117802-1504
R-20	Resistor, Precision	2.5M, ± 0.5%, ½W	50-117802-2504
R-21	Resistor, Variable	250K	127251
R-22	Resistor, Variable (½ Dual Section)	10K	127390
R-23	Resistor, Variable	5K	19-211473-502
R-24	Resistor, Variable (½ Dual Section)	3K	(Part of R-22)
R-25	Resistor, Composition	15K, ± 5%, ½W	5-115557-153
R-26	Resistor, Composition	15K, ± 5%, ½W	5-115557-153
R-27	Resistor, Composition	1.5K, ± 5%, ½W	5-115557-152
R-28	Resistor, Precision	250K, ± 1%, ½W	1-117802-2503
R-29	Resistor, Precision	250K, ± 1%, ½W	1-117802-2503
R-30	Resistor, Precision	1.25M, ± 1%, ½W	1-117802-1254
R-31	Resistor, Precision	350K, ± 1%, ½W	1-117802-3503
R-32	Resistor, Precision	1.25M, ± 1%, ½W	1-117802-1254
R-33	Resistor, Precision	2.0M, ± 1%, ½W	1-117802-2004
R-34	Resistor, Precision	1.25M, ± 1%, ½W	1-117802-1254
R-35	Resistor, Precision	1.25M, ± 1%, ½W	1-117802-1254
R-36	Resistor, Precision	2.0M, ± 1%, ½W	1-117802-2004
R-37	Resistor, Composition	3.6K, ± 5%, ½W	5-115557-362
R-38	Resistor, Composition	3.6K, ± 5%, ½W	5-115557-362
R-39	Resistor, Precision	100K, ± 1%, ½W	1-117802-1003
R-40	Resistor, Precision	100K, ± 1%, ½W	1-117802-1003
R-41	Resistor, Precision	23.5K, ± 1%, ½W	1-117802-2352
R-42	Resistor, Precision	1.1M, ± 1%, ½W	1-117802-1104
R-43	Resistor, Precision	510K, ± 1%, ½W	1-117802-5103
R-44	Resistor, Precision	510K, ± 1%, ½W	1-117802-5103
R-45	Resistor, Precision	1.1M, ± 1%, ½W	1-117802-1104

PARTS LIST (Cont'd)

SYMBOL	DESCRIPTION	VALUE	BRUSH PART NO.
R-46	Resistor, Precision	3M, ± 1%, ½W	1-117802-3004
R-47	Resistor, Precision	470K, ± 1%, ½W	1-117802-4703
R-48	Resistor, Precision	3M, ± 1%, ½W	1-117802-3004
R-49	Resistor, Composition	100K, ± 5%, ½W	5-115557-104
R-50	Resistor, Composition	27K, ± 5%, ½W	5-115557-273
R-51	Resistor, Composition	100K, ± 5%, ½W	5-115557-104
R-52	Resistor, Precision	1.72M, ± 1%, ½W	1-117802-1724
R-53	Resistor, Precision	470K, ± 1%, ½W	1-117802-4703
R-54	Resistor, Precision	470K, ± 1%, ½W	1-117802-4703
R-55	Resistor, Precision	1.72M, ± 1%, ½W	1-117802-1724
R-56	Resistor, Precision	3M, ± 1%, ½W	1-117802-3004
R-57	Resistor, Ballast		119373
R-58	Resistor, Composition	1.1K, ± 5%, 2W	5-115559-112
R-59	Resistor, Variable (½ Dual Section)	1M	126255
R-60	Resistor, Precision	3M, ± 1%, ½W	1-117802-3004
R-61	Resistor, Variable (½ Dual Section)	1M	(Part of R-59)
R-62	Resistor, Composition	10 ohms, ± 5%, ½W	5-115557-100
R-63	Resistor, Composition	10 ohms, ± 5%, ½W	5-115557-100
R-64	Resistor, Composition	500 ohms	20-127785-501
R-65	Resistor, Composition	1.0K, ± 5%, ½W	5-115557-102
R-66	Resistor, Composition	1.0K, ± 5%, ½W	5-115557-102
R-67	Resistor, Composition	2.2M, ± 5%, ½W	5-115557-225
R-68	Resistor, Composition	220K, ± 5%, ½W	5-115557-224
R-69	Resistor, Composition	33K, ± 5%, ½W	5-115557-333
R-70	Resistor, Composition	33K, ± 5%, ½W	5-115557-333
R-71	Resistor, Composition	39K, ± 5%, ½W	5-115557-393
R-72	Resistor, Composition	100 ohms, ± 5%, ½W	5-115557-101
R-73	Resistor, Composition	47K, ± 5%, 1W	5-115558-473
R-74	Resistor, Precision	75K, ± 1%, 1W	1-117803-7502
R-75	Resistor, Precision	50K, ± 1%, 1W	1-117803-5002
R-76	Resistor, Thermal	200 ohms	128196
S-1	Switch, Rotary		227219
S-2	Switch		(Part of R-21)
S-3	Switch		(Part of R-59)
S-4	Switch, Sensitive	D.P.D.T.	127542
S-5	Switch, Toggle	S.P.S.T.	121068
SA-1	Switch Assembly	(Includes R-1 through R-20 and S-1)	427344-910
SR-1	Rectifier		1-127522-5
T-1	Transformer		227396
V-1	Tube, Electron	12AX7	125835*
V-2	Tube, Electron	12AT7	125833*
V-3	Tube, Electron	12AT7	125833*
V-4	Tube, Electron	5687	122828
V-5	Tube, Electron	5687	122828
V-6	Tube, Electron	6BW4	126997
V-7	Tube, Electron	12B4A	124390
V-8	Tube, Electron	12B4A	124390
V-9	Tube, Electron	12AX7	125835
V-10	Tube, Electron	5651	108903
VL-1	Voltage Limiter		127727
WB-1	Board, Printed Wiring (Less Tubes)		326899-910
WB-2	Board, Printed Wiring (Less Tubes)		327395-910

*Replace 12AX7 only with 5751, and replace 12AT7 only with 12AT7WA. 12AX7 or 12AT7 Telefunken, Amperex, or Mullard tubes may also be used.

TUBE SOCKET PIN VOLTAGES

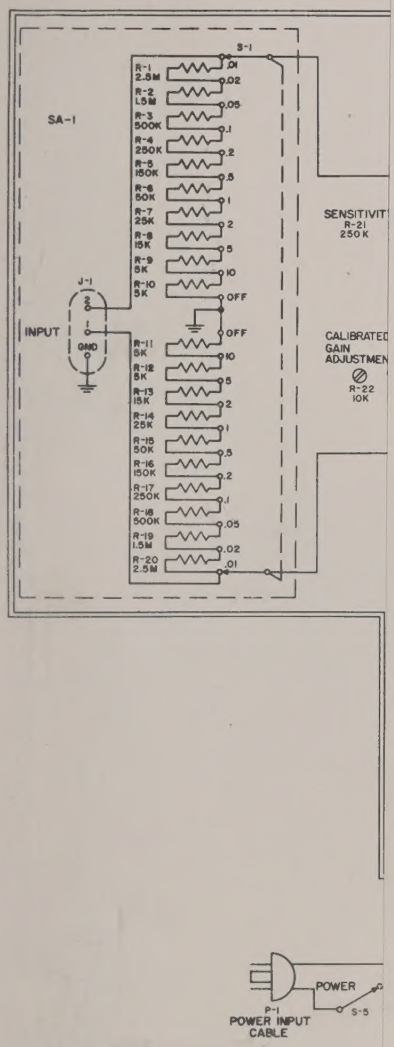
1. Voltages should be measured under the following conditions:
   a. VOLTS/CHART LINE switch in "off" position.
   b. CALIBRATION control full counterclockwise.
   c. Pens at chart center, CHART SPEED "1" button depressed.
2. All d.c. measurements are made with a d.c. voltmeter with a minimum of ten (10) megohms input impedance.
3. All a.c. measurements are made with an accurate RMS a.c. voltmeter (20,000 ohms per volt or higher).
4. All measurements are made from tube pin to —B (⏚) point, except where otherwise noted.
5. Variations in observed voltage readings from tabulated values do not necessarily indicate improper operation unless deviations exceed 10%.

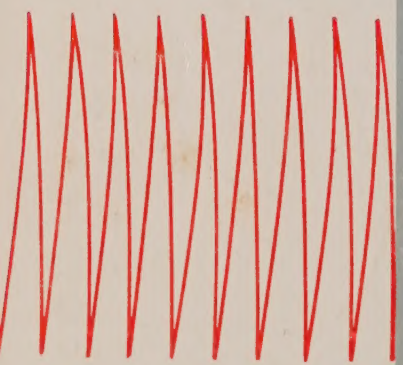
TUBE NO.	TYPE	PIN NUMBER								
		1	2	3	4	5	6	7	8	9
V-1	12AX7	197	92	93	Note 1		197	92	93	—
V-2	12AT7	123	Note 2	54	Note 1		123	Note 2	54	—
V-3	12AT7	115	Note 2	40	Note 1		115	Note 2	40	—
V-4	5687	235	115	119	Note 3		119	115	—	235
V-5	5687	119	24	28	Note 3		28	24	—	119
V-6	6BW4	—	—	—	Note 4		—	—	—	406
V-7	12B4A	235	216		Note 5		—	216	—	406
V-8	12B4A	235	216		Note 5		—	216	—	406
V-9	12AX7	163	86	87	Note 1		216	162	163	Note 1
V-10	5651	87	0	—	0	87	—	0	—	—

NOTES:

1. 6.3 volts a.c. measured from pins 4 and 5 to pin 9.
2. Do not measure.
3. 6.3 volts a.c. measured from pins 4 and 5 to pin 8.
4. 6.3 volts a.c. measured from pin 4 to pin 5.
5. 6.3 volts a.c. measured from pins 4 and 5 to pin 3.

SCHEMATIC DIAGRAM





brush INSTRUMENTS

DIVISION OF

3405 PERKINS AVENUE CLEVITE CORPORATION CLEVELAND 14, OHIO

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